Lat 39.22439 Lon -120.86126

Forest Health Protection

Pacific Southwest Region
Northeastern California Shared Service Area

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To: District Ranger, Yuba River Ranger District, Tahoe National Forest

Subject: Considerations for fire-injured tree harvest and hazard tree abatement within the 2015 Lowell Fire, Tahoe National Forest (FHP Report NE16-01)

At the request of Eric Burke, District Timber Management Officer, Yuba River Ranger District, Danny Cluck, Forest Health Protection (FHP) Entomologist, visited the Lowell Fire with district staff on December 16 and 17, 2015. The objective of this visit was to evaluate the levels of fire injury to conifers, note any insect activity and discuss variables that should be considered when developing fire-injured tree and hazard tree marking guidelines. Recommendations provided in this report will assist in the formulation of silvicultural prescriptions aimed at removing a portion of the fire-injured trees including the abatement of roadside hazard trees.

Description of the project area

The 2,304 acre Lowell Fire, located ~8 miles SE of Nevada City, CA, started on July 25, 2015 and was contained August 4, 2015 (39.224391N and 120.861256E). The elevation ranges from 2,500 – 3,700 feet with annual precipitation ranging between 50 and 60 inches. Forest species composition is primarily ponderosa pine (*Pinus ponderosa*) and sugar pine (*Pinus lambertiana*) with Douglas-fir (*Pseudotsuga menziesii*), knobcone pine (*Pinus attenuata*) and incense cedar (*Calocedrus decurrens*). Black oak (*Quercus kelloggii*) and canyon live oak (*Quercus chrysolepis*) are also present within the fire perimeter.

General observations

Observations were made at the north and south ends of the fire perimeter.

- Large diameter ponderosa and sugar pine (>24” dbh) with only light crown scorching generally had high levels of cambium injury at ground line. This was especially evident on large diameter sugar pine.
- Western pine beetle attacks were observed on fire-injured ponderosa pine. These were

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either single large diameter trees or slightly smaller diameter trees (<24" dbh) concentrated in groups that appeared to have light fire-injuries based on crown scorch.

- Trees that were killed during the fire and had foliage completely consumed were under heavy infestation by woodboring beetles, especially knobcone pine. This activity appeared to be concentrated in the smaller diameter pines (<14" dbh) at this early stage based on the presence of boring dust. The timing of the fire coinciding within the peak flight period for many wood boring beetle species suggests that this condition is widespread within the fire perimeter and will become more apparent over time.

Pre-fire bark beetle activity

FHP aerial detection surveys mapped considerable ponderosa pine mortality caused by western pine beetle (*Dendroctonus brevicomis*) within and adjacent to the Lowell Fire 2015 (ADS July 13-17, 2015). Most of the observed mortality was individual trees and small groups but these were well distributed across the landscape. Mountain pine beetle (*Dendroctonus ponderosae*)-caused mortality of large diameter sugar pine was also observed near the fire area in 2014 and 2015 as well as Douglas-fir mortality caused by either flatheaded fir borer (*Phaenops drummondi*) or Douglas-fir beetle (*Dendroctonus pseudotsugae*). Ground observations of the Lowell Fire and surrounding areas made in December 2015 revealed that the mortality previously mapped by ADS in July 2015 had increased dramatically with large patches of intense ponderosa pine mortality scattered across the entire area (Figure 1). Additional ponderosa pine mortality and top-kill caused by California fivespined ips (*Ips paraconfusus*) was also evident in areas of high western pine beetle activity.

Figure 1. Example of ponderosa pine mortality observed December 2015.

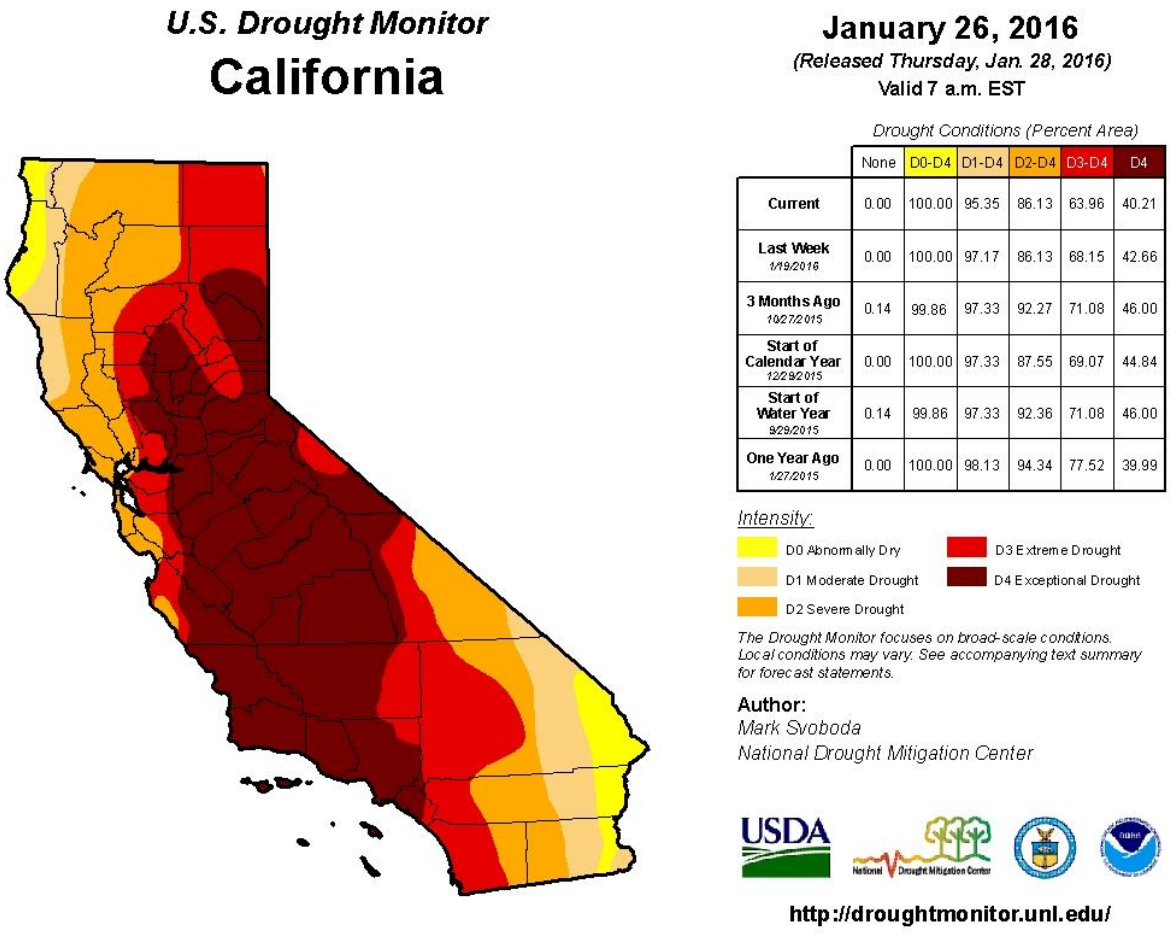
Post-fire bark and woodboring beetle activity

The amount of post-fire insect activity and the resulting tree mortality depends on many factors such as the timing of the fire, the level of insect activity in the area prior to the fire, and stand characteristics. Fire-injured trees are stressed trees and the available soil moisture (pre- and post-fire) can also play a significant role in post-fire mortality. For the Lowell Fire, additional bark beetle activity in fire-injured trees will occur in the spring of 2016 and could continue for 3 to 5 years. High levels of mountain pine beetle activity should be expected in fire-injured sugar pine and western pine beetle activity in ponderosa pine due to the elevated level of pre-fire tree mortality caused by these species. Existing elevated bark beetle populations combined with the high number of fire-injured trees and the extreme drought conditions (US Drought Monitor 2016: Figure 2) will likely lead to major increases in bark beetle/fire-caused tree mortality over the next two years.

The level of fire-injury on an individual tree plays a role in post-fire insect activity. Fire-injured trees can be placed into three categories: 1) those killed outright or injured so severely that they will soon die, 2) those that are lightly injured and should survive, and 3) those in between, the

moderately injured trees. Bark beetles will attack trees in all three categories but successful brood production will only occur in trees with moist cambium. Trees in category one typically do not have enough moist cambium after the fire or if they do, it will become either resin soaked or dry out before beetles can complete their development. Bark beetles attack these types of trees at lower rates and also experience extreme competition from woodboring beetle larvae, reducing reproductive success. Trees in category two provide the highest level of suitable cambium for bark beetles but typically are not injured to the extent that their defenses are compromised. These trees still have the ability to pitch out beetles as they attack, or more often, are avoided by bark beetles altogether. However, based on the current extreme drought conditions, and increased bark beetle activity throughout the Lowell Fire area, the likelihood of lightly fire-injured trees being attacked by bark beetles is greatly increased relative to more normal post-fire conditions. The highest level of bark beetle attacks are likely to occur on trees in category three, the moderately injured trees. These trees will have moderate to high levels of crown scorch and/or cambium injury that compromise their defense systems, putting them at a higher probability of mortality. These trees provide ideal habitat for bark beetles for several years post-fire, especially if cambium injuries are concentrated on the lower bole or at the root collar.

Figure 2. US Drought Monitor, California


U.S. Drought Monitor
California
January 26, 2016
(Released Thursday, Jan. 28, 2016)
Valid 7 a.m. EST
Drought Conditions (Percent Area)
None D0-D4 D1-D4 D2-D4 D3-D4 D4
Current 0.00 100.00 95.35 86.13 63.96 40.21
Last Week 1/19/2016 0.00 100.00 97.17 86.13 68.15 42.66
3 Months Ago 10/27/2015 0.14 99.86 97.33 92.27 71.08 46.00
Start of Calendar Year 12/29/2015 0.00 100.00 97.33 87.55 69.07 44.84
Start of Water Year 9/29/2015 0.14 99.86 97.33 92.36 71.08 46.00
One Year Ago 1/27/2015 0.00 100.00 98.13 94.34 77.52 39.99
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
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National Drought Mitigation Center
USDA
http://droughtmonitor.unl.edu/

The level of woodboring beetle activity in fire-killed trees will become even more apparent in late winter 2016 when woodpeckers begin boring into bark to feed on larvae. Woodboring beetles are likely to attack and successfully reproduce in both moderate and severely fire-injured trees as well as trees killed directly by the fire. Trees that had crowns completely consumed (blackened) are typically the first to be attacked, some within days of the fire. Wood borers will also attack trees that had crowns completely scorched but not consumed (red needles remaining) but initially at a lower intensity than blackened trees. Tree diameter also plays a role as initial attacks tend to be concentrated on smaller diameter trees and the tops of larger diameter trees and then increase and spread into the lower boles of larger diameter trees. Wood borers are not a threat to healthy trees within or adjacent to the burned areas.

The level of wood borer activity and the amount of deterioration to trees designated for harvest can also vary by tree species and size, timing of fire-injury, and by geographic location. For example, among the fires of 2012, the Reading Fire (Lassen NF) had extremely high levels of wood borer activity and associated deterioration of harvest trees one year post-fire while the Barry Point Fire (Modoc NF) and the Chips Fire (Lassen/Plumas NF) had significantly less activity and deterioration over the same timeframe. All of these fires burned in late-July through August. The Reading Fire burned in close proximity to the 2009 Sugarloaf fire (11,269 acres), which may be a partial explanation for the high level of wood borer activity observed within the first post-fire year.

Economic Losses and Potential Hazards Caused by Staining and Decay Fungi

Figure 3. Woodboring beetle galleries (holes in sapwood) and blue stain.

Significant degrade and value losses are highly likely if fire-injured trees proposed for harvest are not removed promptly. Nearly all of the beetles previously discussed carry spores of staining and/or decay fungi that immediately begin to invade sapwood (Figure 3). Blue stain, although not a source of structural degrade, can dramatically reduce the economic value of pine species. Blue stain spreads rapidly into the sapwood and by the end of one year can typically be found in nearly all dead and dying pines. A FHP monitoring study (Eglitis 2006) of 84 fire-killed ponderosa pines in central Oregon found blue stain in 100% of the first 16.5 foot bole sections and in 58% of the second 16.5 foot sections of sampled trees one year post-fire. At the end of two years, 92% of sampled trees had blue stain throughout the entire bole. The occurrence of blue stain within the Lowell Fire is not likely to increase significantly until temperatures warm again next spring/summer and additional bark and wood-boring beetle activity carries staining fungi to more trees. Decay fungi that are introduced typically do not cause significant degrade until after the first post-fire year, with smaller diameter trees decaying faster than large diameter trees.

Sapwood decay can create significant tree hazards in addition to a reduction in economic value. This is particularly true for fire-injured true fir, as surviving trees that develop extensive sapwood decay over the next few years could present hazards to the road system and crews working in burned stands. Previous FHP monitoring of fire-injured trees revealed the failure of 8” to 24” dbh red and white fir, with green crowns, in as little as three years (Figure 4) (FHP Report: SPR-07-

05). The rate of failure increased dramatically after the fourth year, especially in conjunction with high winds or heavy snows. This type of post-fire tree failure was observed in the 1999 Bucks Fire (Plumas NF), 2001 Star Fire (Tahoe NF) and the 2000 Storrie Fire (Lassen NF).

Figure 4. Green fire-injured white fir failure five years post-fire.

Fire-injured tree marking guideline recommendations

The guidelines developed by Region 5 FHP, *Marking guidelines for fire-injured trees in California* (Smith and Cluck 2011) are appropriate for use in the Lowell Fire. The following factors should be considered when selecting the probability of mortality(s) for tree removal:

- the need to expedite tree harvest to capture economic value before significant deterioration and degrade occurs
- the potential for high levels of post-fire bark beetle activity in ponderosa pine and sugar pine due to elevated pre-fire bark beetle activity levels within and adjacent to the burned area
- the current extreme to exceptional drought conditions resulting in increased moisture stress on individual trees
- the need to reduce the number of fire-injured trees along roadsides that have a high probability of mortality
- the need to meet post-fire fuels objectives
- the need to meet post-fire wildlife objectives
- the need to meet reforestation objectives

Since the Lowell Fire burned later in the growing season, ponderosa pines had mostly finished needle growth by the time their crowns were scorched. Therefore, the crown scorch guideline for yellow pine (pre-bud break) should be used to mark these species at this time. If tree marking continues next spring/summer (or is delayed until that time), the crown kill guideline for yellow pine (post-bud break) should be used as soon as new growth is clearly visible throughout the crown. The red turpentine beetle guideline is also not recommended until bud-break in May/June 2016 due to the timing of the fire. Cambium sampling is highly recommended due to the high levels of injury observed at the base of large diameter ponderosa and sugar pine and the relatively minimal effort required to inspect trees within the small acreage designated for fire-injured tree harvest. If possible, waiting to mark ponderosa and sugar pine after red turpentine beetles become active in the late spring will provide better information to make more accurate decisions on individual trees.

The probability of mortality (Pm) often selected for post-fire projects in California is 0.7. A Pm of 0.7 is a relatively conservative guideline in that a land manager can be fairly certain that a tree marked at this level is likely to die within the next 5 years. Marking fire-injured trees at this level has had mixed results in meeting project objectives as trees that have a Pm of 0.1 to 0.6 are left on the landscape. In some cases, many of these "leave trees" have ended up dying. For some recent

fire-salvage projects that have occurred during the current drought, a Pm=0.7 has proven too conservative. This has led to the need to conduct additional salvage and roadside hazard projects to meet management objectives.

In order to compensate for the impacts of the current extreme drought and high levels of bark beetle activity that is expected in fire-injured trees, a more aggressive guideline should be selected to meet management objectives. Current conditions and recent observations of delayed fire-injured tree mortality indicate that selecting a lower probability of mortality threshold is the best way to insure that post-fire management goals are met (Appendix A).

Guideline alternatives:

1) *Only mark and remove trees with no green needles* - This will insure that no tree will be removed that may have otherwise survived its fire-injuries. This will also result in a large number of trees remaining on the landscape that will ultimately die from fire-injury and subsequent bark beetle attack. These dead trees may have to be felled and/or removed at a future date, at high cost, to facilitate tree planting, reduce large woody fuel loading and/or mitigate tree hazards.

2) *Mark all trees at the Pm=0.7 level* - Under more normal precipitation and bark beetle activity this would be a conservative, yet reasonable approach to meet post-fire objectives. Especially if the ability to harvest additional trees as they die (trees that didn't initially meet the mortality threshold) is built into sale contracts. Under the current conditions, this conservative approach is expected to result in nearly the same scenario as Alternative #1, where large numbers of trees will remain on the landscape that will ultimately die from fire-injury and subsequent bark beetle attack.

3) *Mark trees at a lower Pm level to compensate for the current extreme drought and high level of bark beetle activity* – This alternative is the best approach to address the expected high levels of delayed fire-injured tree mortality. This approach will help capture the economic value of dead and dying trees in a timely manner without the need for future entries to meet management objectives. Suggested marking guidelines are as follows:

    - <u>A Pm of 0.4 for yellow pine and sugar pine with cambium sampling.</u> This guideline would help capture most of the expected post-fire tree mortality within treatment units to meet project objectives of capturing economic value, reducing fuel loads, mitigating roadside hazards and reducing the number of harvest entries.

    - <u>A Pm of 0.6 for Douglas-fir and incense cedar, no cambium sampling.</u> The rationale for this guideline is the same as above but is more conservative for these species as they are not expected to experience the same intense bark beetle pressure as pine species.

    All trees should be assessed for evidence of significant bark and/or woodboring beetle activity as described in the guidelines.

Hazard tree marking guidelines

Region 5 FHP hazard tree guidelines (Angwin et al 2012) clearly define failure and target potential to help land managers make more informed decisions for hazard tree abatement projects. In using these guidelines for roadside hazards, the district will need to decide which trees need to be removed based on the failure potential rating of any defect(s) found (including fire-injuries) and the "Exposure Duration" (Long, Short or Intermittent With High Frequency), which reflects such factors as road maintenance level, traffic volume, and degree to which people stop and congregate.

Please keep in mind that the FHP hazard tree and fire-injured tree guidelines are addressing different subjects. The fire-injured tree marking guidelines are predicting tree mortality, not failure potential. The hazard tree guidelines predict tree failure potential, not tree mortality. Both can be used along roadsides to abate existing tree hazards due to defect and remove trees that are likely to die from fire injuries and pose a hazard in the near future. Both guidelines have been provided to the Yuba River Ranger District.

Treatment of cut stumps to prevent Heterobasidion root disease

Fresh cut stumps of fire-injured trees can provide entry courts for Heterobasidion root disease (*Heterobasidion occidentale and H. irregulare*). Stumps of trees killed by fire that have been dead less than 18 months should also be considered susceptible. Therefore, it is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" dbh in order to reduce the chance of new Heterobasidion root disease centers being created through harvest activity. However, treatment of stumps may not be beneficial in high severity harvest areas where no green trees remain.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

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Appendix A

Forest Health Protection
Pacific Southwest Region

Fire-injured tree marking guideline considerations for drought and elevated bark beetle populations

Summary

The current drought is unprecedented in many areas of California. In the most severely affected areas, drought and bark beetles are causing elevated tree mortality in nearly all conifer species. This includes fire-injured trees in recently burned areas which are now at a higher risk of mortality than would be expected under more normal precipitation conditions.

Drought, bark beetles and fire injuries are contributing to ongoing tree mortality in the footprints of the American Fire (TNF 2013), Barry Point Fire (MDF 2012), Reading Fire (LNF 2012), Chips Fire (PNF, LNF 2012), Aspen Fire (SNF 2013), and likely others in the Region. Most noticeable is the high level of mountain pine beetle-caused mortality of fire-injured sugar pine.

Based on these observations:

1) Land managers may want to survey previously salvaged wildfire areas to capture additional mortality depending on management objectives.
2) For restoration projects planned for 2014 and current year wildfires, land managers should consider selecting a lower probability of mortality (see discussion below) threshold to compensate for the potential increase in fire-injured tree mortality or plan to extend contracts to capture additional delayed mortality.
3) Land managers are advised to use additional marking guideline criteria such as cambium kill and the presence of red turpentine beetle attacks for sugar pine.
4) Please consult Forest Health Protection (FHP) staff for assistance.

The marking guidelines developed for most R5 fire-salvage and hazard tree abatement projects are based on *Marking guidelines for fire-injured trees in California* (Smith and Cluck 2011) and *Hazard Tree Guidelines For Forest Service Facilities and Roads in the Pacific Southwest Region* (Angwin et al. 2012). The probability of mortality (Pm) typically selected is 0.7 for salvage and roadside hazard units. In roadside units, trees are also evaluated for structural defects and marked if they meet high failure potential thresholds. Cambium sampling is generally not conducted due to time constraints and the additional work load relative to the small increase in guideline accuracy using this variable provides. Red turpentine beetle attacks are often not assessed due to the timing of timber marking occurring before the first post-fire beetle flight.

A Pm of 0.7 is a relatively conservative guideline in that a land manager can be fairly certain that a tree marked at this level is likely to die within the next 5 years. As a result, many trees that have a Pm of 0.1 to 0.6 are left on the landscape and could ultimately die whether it is from fire-injury alone or a combination of fire-injury, bark beetle attack and drought. Sale contracts that allow for additional volume and time can enabled land managers to keep removing trees as they die to successfully meet post-fire management objectives. Contracts that are less flexible can result in an inability to remove delayed mortality, leaving an excessive number of dead trees on the landscape.

Another aspect of how well a Pm of 0.7 will meet post-fire management objectives is simply the number of fire-injured trees that will remain post-initial harvest. Fires that are mostly high severity and kill trees immediately may have very few

low and moderate severity burned acres, so there is less likelihood of higher levels of delayed mortality. Fires that have a large number of acres of low to moderate severity have a higher probability of experiencing delayed mortality over several years. Fire-injured trees are stressed trees and the available soil moisture (pre- and post-fire) as well as the amount of bark beetle activity in the area can play a significant role in post-fire mortality. Therefore, depending on the type of burn severity and post-fire management objectives, choosing a lower probability of mortality threshold may be warranted under current drought conditions.

High levels of mountain pine beetle activity have been observed over the past few years in sugar pine, and even more so in fire-injured sugar pine. To help capture some of this mortality during fire restoration projects, land managers should consider utilizing the cambium kill criteria as well as the red turpentine beetle criteria in marking guidelines. High levels of cambium kill have been observed by FHP on larger diameter sugar pine in most wildfire areas over the past 15 years and trees that have extensive cambial injury are highly attractive to mountain pine beetles, even at lower levels of crown kill. Sugar pine can generally sustain higher levels of cambium kill than other tree species but can be particularly vulnerable to mountain pine beetles at higher injury thresholds. Hood et al. (2010) found that when holding crown injury constant, sugar pine mortality increased only slightly until all cambium quadrants sampled were dead (CKR = 4), which follows past findings that sugar pine is capable of withstanding more extensive cambial injury than other California conifers (Wagener 1961). Hood et al. (2010) also observed that mountain pine beetles attacked 81% of the subset of sugar pines (170 of 210 assessed trees) that subsequently died in the Power Fire (ENF 2004). The Region 5 FHP fire-injured tree marking guidelines for sugar pine highlight how a high level of cambium injury affects sugar pine survival. These guidelines show that with up to three dead cambium samples (CKR=3) the crown kill criteria for sugar pine need to be adjusted up 5% for a given probability of mortality. That means a tree with that level of cambium injury would require 5% more crown injury to be marked for removal. However, when a tree has four dead samples (CKR=4), the crown criteria need to be adjusted down by 20%. Crown criteria are also reduced with the presence of red turpentine beetle.

If you are using FHP marking guidelines for your post-fire restoration project, it is imperative that you contact your local FHP service area staff for review of your draft NEPA document (before public distribution) and for assistance with responses to comments, marking guideline selection and project implementation.

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References:

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